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With international search report.

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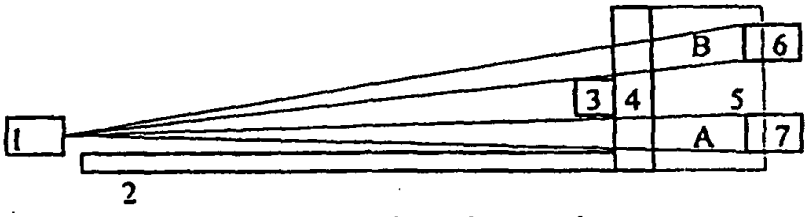
(54) Title: MONITORING DUST DEPOSITION

(57) Abstract

A method and a means for monitoring a contaminated or inflammable condition in an appliance or an installation is based on measuring deposited amount of dust on a surface in the appliance/installation. A measurement device of optical, thermal or mechanical type is attached signal–wise to an indicator that displays a value or provides an indication of a parameter attached to the deposited amount of dust.



Dustdetektor from side

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MONITORING DUST DEPOSITION

The present invention relates to monitoring a contaminated, dirty or inflammable condition caused by fallout dust. More specifically, the invention is directed to a new use of dust detection equipment to give warning of the presence or amount of dust or fine particles on a surface in an appliance.

A main purpose of an indicator for fallout dust is the prevention of fire and explosions. However, one may envisage several important purposes, e.g. (a) being able to prevent particular odour related to dust/particle accumulations, (b) being able to improve the efficiency of e.g. cooling units by preventing large accumulations of dust on cooling ribs, such accumulations impairing heat exchange capability, (c) general improvement/ increasing efficiency of cleaning/service/maintenance programs, i.e. demonstrating more easily a need for cleaning, (d) being able to maintain important parameters for electrical/electronic apparatuses within given tolerances.

In general it is previously known to measure dust and particle accumulations, however such measurements are typically made in industrial or research related environments. US patent no. 4,793,710 discloses e.g. a method for measuring dust layers in coal mines, based upon an optical technique, and US patent no. 5,412,221 also relates to an optical measuring method for small particle depositions ("fallout") in connection with space research. US patent no. 5,229,602 discloses an optical method for detecting contamination layers particularly on transparent surfaces (headlight glass, windshield) on vehicles.

However, the present invention is based on a need for safeguarding life , health and property also in a normal consumer environment, and then based upon solutions that can be mass produced at a low cost, especially in such a manner that measurement and display equipment can be integrated in an appliance that is usual in such a normal consumer environment.

In a consumer market that comprises products of the type TV sets, audio and video appliances, larger domestic appliances like refrigerators, stoves, etc., small domestic appliances like coffee makers etc., personal care appliances, computer products like PC's and additional equipment for such products, electrical installations in dwelling units like fuse boxes/panels, electric radiators, lamps etc., it is clear that a dust monitor may be of large interest, also in connection with the

allergy problems from which many people suffer. A good indication of dust accumulation in the close environment of an allergic subject may provide a good basis for demonstrating the efficiency of possible counter measures, or provide a basis for starting such counter measures.

As regards ordinary cleaning, a dust monitor in accordance with the invention can of course also be an aid quite simply in demonstrating the need of ordinary cleaning.

When the word "dust" is used in the present description of the invention, and in the patent claims, one has in mind dust of different types, fine particles, dirt etc. A starting point is that the dust in question is fallout dirt consisting of particles that may hover some time in the air. Additionally, within the concept of dust, it is possible to distinguish between house dust, industrial dust and traffic dust. House dust is a mixture of fabric fibers (various forms of fabrics like cotton), and pollen (different forms of pollen, i.e. grain, grass, flower pollen etc.). Industrial dust is various types of waste products like grinding dust from wood and metals, and other waste products (contamination, pollution). Traffic dust is a mixture of asphalt, exhaust and different types of gases (pollution).

Hence, the purpose of the invention is to provide a warning/indication regarding accumulation of dust in important positions for consumers, and in accordance with the invention this has been achieved through a use of the type defined in the appended patent claims.

In the following the invention shall be illuminated further by examining certain exemplary embodiments, and in this connection it is referred to the appended drawings, where

figs. 1a and 1b show schematically a dust meter of optical type, in views from above and from the side,

fig. 2 shows a circuit diagram for an optical detector used in the dust meter shown in figs. 1a and 1b,

figs. 3a and 3b show a dust meter of thermal type, in views from above and from the side,

fig. 4 shows a circuit diagram for a detector in connection with the thermal dust meter shown in figs. 3a and 3b, and

fig. 5 shows a dust meter that can be used in accordance with the invention, in its most general form.

A concrete use of the invention is, as mentioned above, in connection with detecting and giving warning regarding dust accumulation in a TV set. The embodiments now to be discussed with reference to the drawing are envisaged in such a connection, but it is emphasized once more that also other consumer appliances are of interest, as explained previously. In figs. 1 a and 1b appears a schematic layout for a dust meter that is mountable inside a TV set. A plate 2, preferably arranged horizontally will little by little accumulate dust and particles that are deposited from the air space above the plate. A light source 1 is arranged at the left end of the plate 2, which light source emits light in such a manner that it propagates at least along the top side of the plate 2, and in addition in a space above the plate that supposedly does not contain any dust, i.e. in such a height above the plate that it is improbable that a dust layer will ever grow that high. The two main light paths appear in fig. 1b, i.e. two light paths indicated by means of two divergent pairs of broken lines. (Light may of course also spread outside these directions, but such light will not be of any use in connection with the actual measurement.)

A screen 3 provides a division between the two light beams of interest, the two light beams being termed A and B, i.e. A in the dust layer area, B in the air space above the dust layer.

As appears from fig. 1a, it is favourable to have a wide light beam, or making the light beam spread such as shown in the figure 1, along the dust layer, in order to increase measurement sensitivity and to decrease uncertainty. A lens 4 collects both beam parts A and B to respective detection areas, where two separate detectors 6, 7 measure light intensities. The lens 4 may be a normal convex lens, or, such as indicated in the figure, a cylinder lens, since it may be sufficient to focus the light in the horizontal plane. It will be favourable to build both detectors 6,7, the lens 4 and the screen 3 together inside a closed box 5, indicated in the figure by broken lines.

The intensity of light beam A will be reduced when the dust thickness on plate 2 grows, while the reference light in beam B will not be influenced by this layer of dust. Dust on the light source 1 will attenuate both beams equally. It is possible to adjust the recordable dust thickness mechanically by adapting the height of the light slit between screen 3 and plate 2. The top surface of plate 2 should be dull so as to avoid reflections. As mentioned, it is favourable with a light

beam having a certain width in the horizontal plane, and this can e.g. be achieved by means of a (not shown) lens between the light source and plane 2, or by making the light source emit a relatively wide beam such as shown in fig. 1a.

Regarding the electric/electronic aspect of this matter, it is referred to fig. 2 which shows an easily realized design of the electrical circuitry that is necessary in connection with the configuration of fig. 1a/1b. The light source 1 is shown in a simple circuit at the left in the figure, in the form of a light-emitting diode (LED), and in the detection circuit to the right in the figure, detectors 6 and 7 are shown as phototransistors connected in a simple manner to provide input signals for a differential amplifier 8 (it is also possible to use photodiodes.) As the dust thickness increases, and thereby beam A is attenuated, the ratio between the two voltage inputs to the differential amplifier is upset, and the voltage output form the differential amplifier 8 will e.g. increase. This is detected by means of the comparator 9 which compares to a fixed reference voltage delivered by a simple voltage divider. If the output from comparator 9 exceeds a certain voltage, the alarm light diode 10 is switched on, and this represents a possible indication that an undesired thickness of the dust layer has been reached.

The electronic circuitry after the photo detector 6,7 will in reality depend on how the possible dust recordal shall be indicated, i.e. if, such as shown here, a light diode shall be lit, if a measurement value shall be exhibited in a display, or possibly in a TV screen, or a special indication may also be cutting the supply voltage of the TV set..

Hence, in the shown embodiment, the exceeded dust limit is marked by lighting a light diode, and by outputting a logic "high" signal. However, it is quite feasible to grade the alarm for indicating several thicknesses of dust, but this will then require a somewhat different circuit solution than what has been shown.

If the detector is to be located in an area where light can get in, the light source 1 should be modulated so that the receiver part can be AC coupled, such a solution has not been shown in the drawings either. The solution with a modulated light source will of course be a little more costly.

As a matter of principle, it will of course also be possible to transmit light "transversely" to the dust layer, that is in fig. 1b with a light source situated above plate 2, preferably with a light beam expanding element in the form of a lens, with a transparent or reflecting plate 2, and with detection below or above the plate

respectively. A reference measurement must then be made in some other manner, e.g. with a detector attached to the light source in a dust-free configuration, i.e built-in together with the light source.

Experiments that have been conducted in accordance with the solution shown in figs. 1a, 1b and fig. 2, show that the light traveling along the dust surface, will be attenuated approximately in proportion to the dust thickness. The experiments further indicate that the density of the dust layer is of little importance with this detection solution.

Quite different measurement techniques than optical detection can also be used regarding detecting dust layers, and in fig. 3a and 3b is shown a thermal detector for the same purpose. The principle utilized here, is based on the fact that a dust layer will have an insulating effect, so that the temperature in a heated surface will increase with increasing dust thickness. To achieve a reliable detection, a reference measurement toward a point that does not depend on the dust layer, should be used.

The thermal detector is built on an insulating support D in order to maintain a heat loss that is as small as possible in that direction. Heating elements may be two resistors 11 and 12 connected in parallel and placed on respective cooling surfaces 15 and 26, as shown in fig. 3a which is a top view of the detector. The cooling surface 15 is the actual dust sensor, which little by little shall be coated by dust, while cooling surface 16 is a reference. Cooling surface 16 is made insensitive to dust by covering it by an insulation layer E that is not too thick. Here it is a goal that the thermal resistance through insulation layer E shall be significantly higher than the thermal resistance in a dust layer, so that such a dust layer does not influence the heat emission from the cooling surface. In order to obtain sufficient cooling despite this, that surface is made relatively large.

Thermistors are preferably used as temperature sensors 13 and 14. (Other types of sensors are of course also of interest, e.g. thermocouples.) The dust sensor, i.e. the cooling surface 15, will have a reduced cooling effect when it is gradually covered by a dust layer, so that the temperature in the thermal sensor 13 will be a function of the dust thickness. The temperature in thermal sensor 14 will on the other hand stay substantially constant, even if dust falls upon the insulation layer E.

Closely adjacent to the thermal sensors 13 and 14 the temperature should be substantially higher than the ambient temperature. This is achieved by supplying sufficient power (about 1-5 watt), and by insulating above the thermal sensors and the heating elements (insulation layer C). The physical dimensions may be about 5 x 5 cm, and with a maximum height about 2 cm, see fig. 3b.

An example of a circuit diagram in connection with the thermal detector shown schematically in figs. 3a and 3b, appears from fig. 4. In the example in fig. 4, the end part of the detection circuit is rather similar to what appeared from fig. 2 regarding the optical detection circuit, i.e. from the differential amplifier 17 through the comparator 18 and to an alarm light-emitting diode 19. However, the photo-transistors 6 and 7 in fig. 2 are changed for thermistors 13 and 14 in fig. 4, for delivering signal voltages to the differential amplifier 17. Each one of the thermistors 13 and 14 is part of a voltage divider together with resistors, R2 and R1 respectively. The heating elements 11 and 12 are part of a separate, simple parallel circuit.

All resistors in the disclosed circuit, including the heating elements, should have a tolerance of 1% or better, while the accuracy of the supply voltage U is not critical.

Both the described solutions for detecting dust layer thickness are simple, and the total cost in mass production can be expected to be less than NOK 10 in both alternatives, the thermal solution being the cheaper one.

One further possibility for detecting a dust layer is a mechanical sensing method, which method can be based upon a strain principle or a pressure principle. The strain principle is based on bending a plate due to the dust weight. In such a case a strain gauge may be the actual sensor. When the pressure principle is used, a pressure sensor on the underside of an accumulation surface senses the weight of the dust layer, that is the superpressure coming gradually in addition to the start pressure caused by the weight of the surface/plate itself.

Independent of the type of sensor that is used, a signal from the sensor will normally have to be amplified, i.e. the amplifier succeeding the sensor, shall record current or voltage from the sensor, and adapt the level for the display unit that may be of various types. In order to make relative measurements, the amplifier should be a differential amplifier with the sensor in a measurement bridge.

Regarding the display unit, this unit may be of several different types. As shown in fig. 2 and fig. 4, display takes place by means of a simple light-emitting diode, which is lit when the dust layer reaches a certain thickness. It is of course also possible with a display of a more advanced type, e.g. for displaying the actual thickness of the dust layer, measured by means of a suitable unit of measure. A seven-segment type display or an intelligent display may then be utilized. Further possibilities are that the display unit may control a current switch for switching off the appliance in question if the dust thickness exceeds a critical value. Further possibilities include connection to a monitor screen with an opportunity for text in the screen. This last mentioned solution may e.g. be of interest if the dust monitor shall be built-in in an integrated manner in a TV set or a computer monitor.

In this last mentioned case it is favourable to manufacture the dust warning unit as an individual unit, or possibly as an integral part of an appliance. If the dust warning unit is produced as an individual unit, it must be suitable for fitting into the appliance at a later time. As an integral part, it will be included as a production element in an appliance, e.g. a TV set, and as previously mentioned, possibly at a very low cost.

The voltage supply may be standardized e.g. at 5,0 volts. This voltage may vary within a given range, without influencing the reliability of the dust monitor.

As previously mentioned, it is favourable to base the dust sensor on relative measurements, so that external and spurious influences shall not be disturbing.

Quite generally it is important to underline that the "warning" that shall take place, may take place in different manners. As mentioned above, one may most easily visualize a light indicator in some form (one further such indicator may be a simple luminous indication with a colour dependent on dust amount), but it may also be of interest to use an acoustic signal, i.e. some form of sound emission, and a text indication as mentioned above in connection with a TV set/computer monitor, is an important possibility. Of course, one may also visualize a combination of these indication modes.

It seems also favourable in certain applications to have the possibility that the display may provide information that the system is operational, and that it is working.

In fig. 5 appears a dust measurement device in its most general form, as mentioned above, i.e. independent of the physical measurement principle that

may be optical, thermal, weight-based, ultrasound-based, possibly based on measurement of electrical characteristics like resistance, capacity etc. Absorption/attenuation of other types of radiation than optical and ultrasound radiation can be envisaged, e.g nuclear radiation with a radiation source similar to the one that is utilized in smoke detectors. Thus, in this figure "the dust sensor", which normally will require a voltage supply, comprises some sensor type that is able to deliver a signal depending on the dust amount that is measured. The signal passes to an amplifier that delivers an output signal further to a display unit and possibly to an alarm unit. The display unit may preferably comprise or be attached to a monitor screen, and it may possibly be switchable on/off by means of a switch.

PATENT CLAIMS

1. Use of a measurement device (1, 6-9; 11-14, 17, 18) for measuring a parameter indicating amount of dust deposited on a surface, and of an indicator (10, 19) signal-wise connected to the measurement device for specifying an indication of the parameter,
for monitoring a contaminated, dirty or inflammable condition in an electrical consumer appliance, e.g. a TV set.

2. Use of an optical measurement device (1, 6-9) for measuring attenuation of a light beam (A) transmitted through an amount of dust deposited on a surface, and of an indicator (10) connected to the measurement device (1, 6-9) for specifying a measurement value that is a function of the attenuation,
for monitoring dust thickness in an electrical consumer appliance, e.g. a TV set.

3. The use of claim 2, wherein the output intensity of the through light beam (A) is compared to the intensity of a reference light beam (B) passing outside the amount of dust.

4. The use of claim 2 or 3, wherein the light beam (A) is transmitted along and through the dust layer, possibly as a divergent or expanded beam to increase measurement sensitivity, and which beam is then possibly focused towards a photodetector (7) by means of a lens (4) situated after said surface.

5. The use of claim 2 or 3, wherein the light beam is transmitted substantially transversely to the dust layer, possibly with a reflection against the underlying surface so that the dust layer is passed twice before detection.

6. Use of a thermal measurement device (11-14, 17, 18) for measuring heat insulating ability for an amount of dust deposited on a surface, and of an indicator (19) connected to the measurement device for specifying a measurement value that is a function of said heat insulating ability,
for monitoring dust thickness in an electrical consumer appliance, e.g. a TV set.

7. The use of claim 6, wherein temperature is measured by means of a temperature sensor (15) in an object that is thermally closely attached to said surface, heat being supplied to said object (15) by means of a heating element, so that said surface emits heat radiation, said emission being dependent on the thickness of said dust layer.

8. The use of claim 7, wherein temperature is also measured in a reference object (16) which is not subject to coating by dust, and in a corresponding manner as in said object (15), known and possibly equal power being supplied to the object (15) and the reference object (16), and a comparison between the measured temperatures constitutes a basis for specified measurement value from the indicator (19).

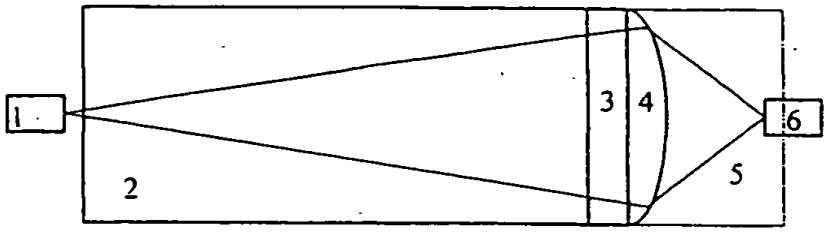
9. Use of an ultrasound measurement unit for measuring attenuation of ultrasound energy transmitted through an amount of dust deposited on a surface, and of an indicator connected to said ultrasound measurement unit for specifying a measurement value that is a function of the attenuation,
for monitoring dust thickness in an electrical consumer appliance, e.g. a TV set.

10. Use of a pressure sensor for measuring superpressure caused by an amount of dust deposited on a surface, and of an indicator connected to the pressure sensor for specifying a measurement value that is a function of said superpressure,
for monitoring dust weight in an electrical consumer appliance, e.g. a TV set.

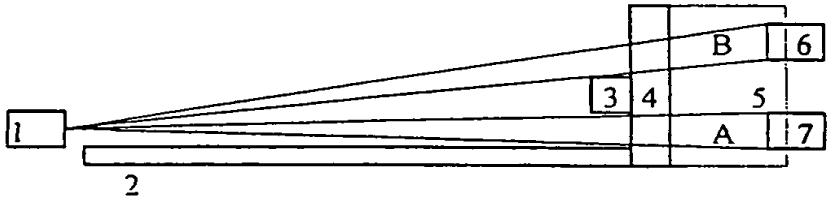
11. Use of a strain sensor for measuring degree of flexure for a plate that is subject to the weight of an amount of dust deposited on a surface on the plate, and of an indicator connected to the strain sensor for specifying a measurement value that is a function of the degree of flexure,
for monitoring dust weight in an electrical consumer appliance, e.g. a TV set.

12. The use of any one of claims 2-11, wherein said indicator displays continuously a measurement value on an analog scale or by digital display.

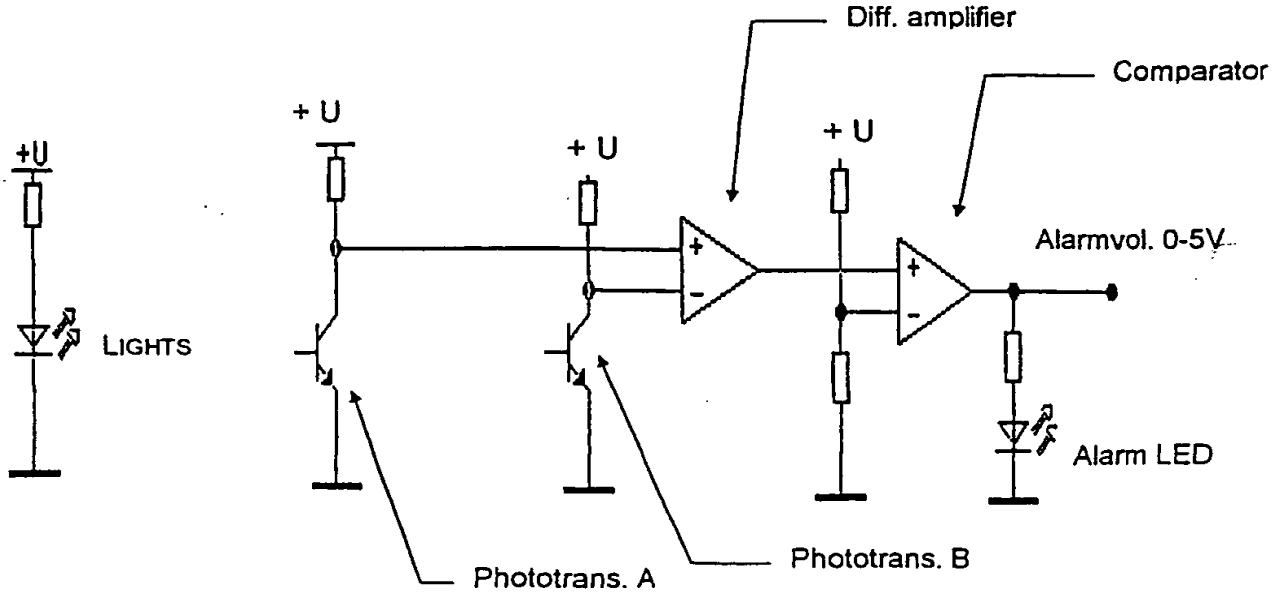
13. The use of any one of claims 2-11, wherein said indicator indicates the exceeding of a threshold value for said measurement value by delivering a warnng signal that may be of an optical or acoustical type, possibly both.



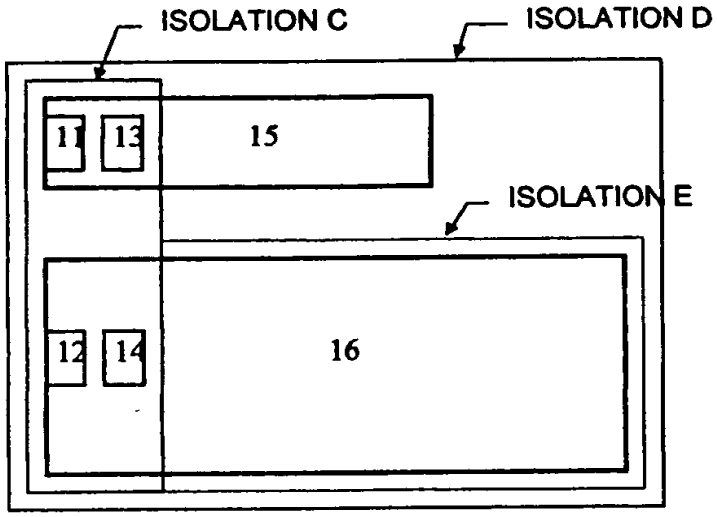
Figur 1a Dustdetektor from top



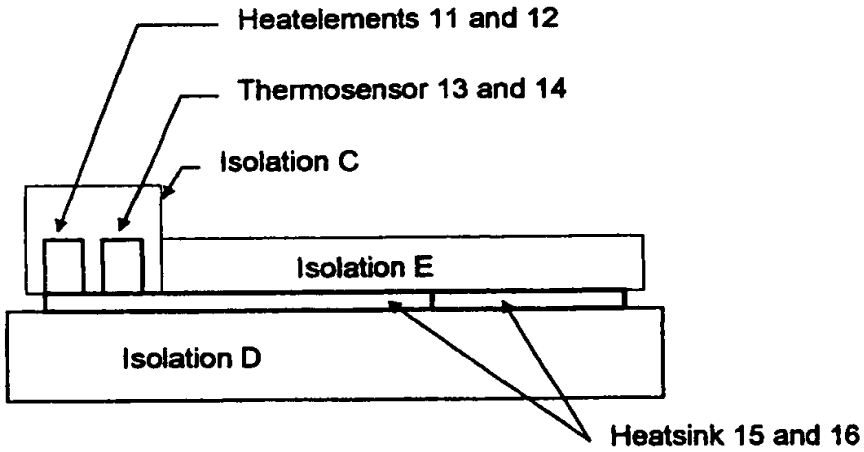
Figur 1b Dustdetektor from side



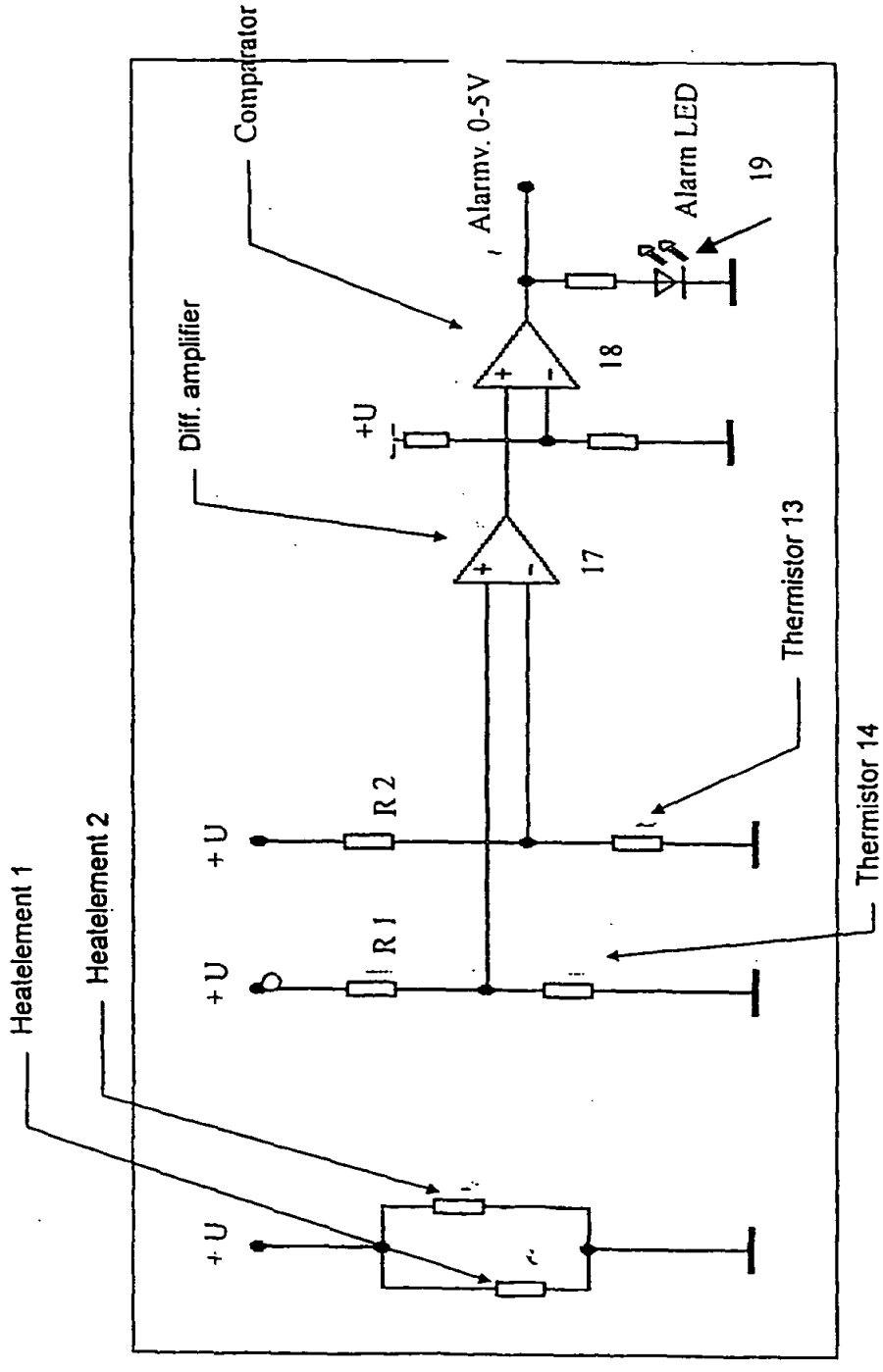
Figur 2 Schematic diagram for optisk detector



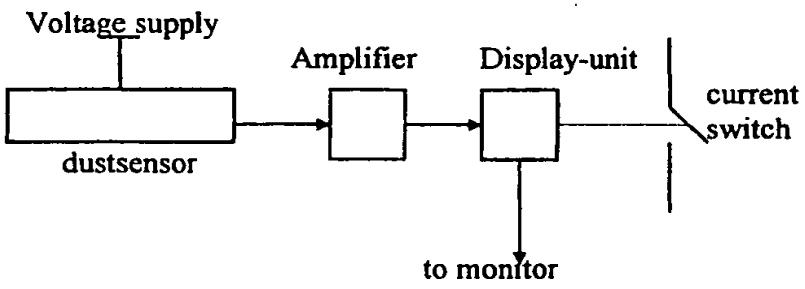
Figur 3a Thermic detector from top



Figur 3b Thermic detector from side



Figur 4 Schematic diagram for thermic detector


Voltage supply
Amplifier
Display-unit
current
switch
dustsensor
to monitor

Figur 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 98/00121

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01N 21/47
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, TXTE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5412221 A (IHLEFELD M. CURTIS ET AL), 2 May 1995 (02.05.95), column 3, line 21 - line 38; column 4, line 8 - line 23, figures 2,3, claim 1	1-5,12,13
X	US 3777173 A (JAMES EDWARD LANDRITH), 4 December 1973 (04.12.73), figure 4, abstract	1-5,12,13
X	US 4793710 A (MICHAEL J. SAPKO ET AL), 27 December 1988 (27.12.88), column 3, line 50 - line 66, abstract	1,2
A		3-5

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 August 1998	20 -08- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Johan von Döbeln Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 98/00121

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4916325 A (ANTHONY P. ROOD ET AL), 10 April 1990 (10.04.90)	1
A		2-5,12,13
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X	US 5229602 A (PETER JÜLIGER), 20 July 1993 (20.07.93), column 1, line 8 - line 42	1
A		2-5
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INTERNATIONAL SEARCH REPORT

International application No.
N098/00121

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-5,12,13

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
NO98/00121

I. Claim 1 directed to the use of a measuring arrangement for measuring the amount of dust on a surface.

II. Claim 2-5, 12, 13 directed to the use of an optical measuring arrangement for measurement of a light ray passing through the dust on a surface and for indicating the amount of dust on the surface.

III. Claim 6-8 directed to the use of a thermal measuring arrangement for measurement of the thermal insulation of dust on a surface and for indicating the amount of dust on the surface.

IV. Claim 9 directed to the use of an ultra-sonic sensor for measurement of the amount of dust on a surface.

V. Claim 5 directed to the use of a pressure sensor for measurement of the amount of dust on a surface.

VI. Claim 11 directed to the use of a strain sensor for measuring the amount of dust on a surface.

The special technical features of these groups are:

Group I: the use of a measuring arrangement for indicating the presens of dust or dirt in an electrical apparatus.

Group II: the use of an optical measuring arrangement for measurement of the amount of dust.

Group III: the use of a thermal measuring arrangement for measurement of the amount of dust.

Group IV: the use of an ultra-sonic measuring arrangement for measurement of the amount of dust.

Group V: the use of a pressure sensor arrangement for measurement of the amount of dust.

Group VI: the use of a strain sensor arrangement for measurement of the amount of dust.

Th se groups of inventions are not so linked as to form a single general inventive concept. There is no technical relationship among those inventions involving one or more of the same or corresponding technical features.

INTERNATIONAL SEARCH REPORT

Information on patent family members

27/07/98

International application No.
PCT/NO 98/00121

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